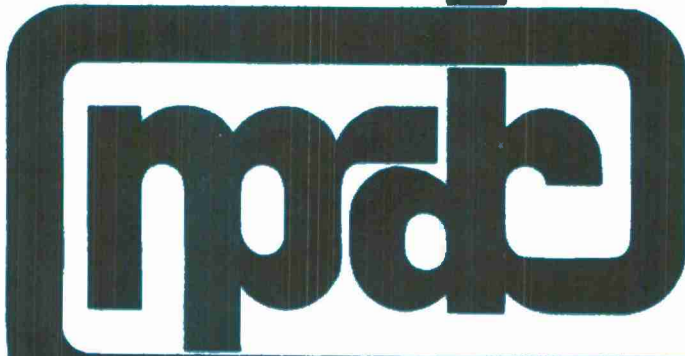


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**AN EVALUATION OF THE USE OF
CHEMICALLY TREATED ANSWER SHEETS**

**Larry G. Harding
Phyllis A. Salop
Kirk A. Johnson**

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This study was an evaluation of chemically treated answer sheets as part of a system of Computer Managed Instruction. The performance of a group of students using chemically treated answer sheets was compared with that of a group using optically scannable sheets in terms of time to complete course material and errors on an end-of-course test. The results of the study indicate that training time was reduced about 15% by means of the chemically treated answer sheets and associated changes in procedures.

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SUMMARY

Problem

The Computer Managed Instruction system developed at Memphis provided feedback on tests by means of delayed computer printouts. There was a variety of problems associated with this method. The purpose of this study was to explore the use of chemically treated answer sheets as a means for solving some of these problems.

Background and Requirements

The chemically treated answer sheets allow the student to see whether his answer is correct immediately after he makes a response. Further, the answer sheet is self scoring. Thus, it can be used to provide an immediate indication of the areas in which the student needs remediation. It seemed pertinent to test the value of these features in a training situation. A portion of the AMFU (Aviation Mechanical Fundamentals) Course was used for this purpose.

Approach

The performance of a group of students who used the chemically treated answer sheets in part of the AMFU course was compared with the performance of a group who used optically scannable sheets in learning the same material. The two groups were compared in terms of (1) the time required to complete the portion of the course where the chemically treated sheets were used and (2) the number of errors made on those items from the end-of-course examination which pertained to material covered during that portion of the course.

Findings

The group using the chemically treated answer sheets was found to require reliably less training time in the portion of the course which was evaluated. Training time was reduced about 15% by means of the chemically treated answer sheets and associated changes in procedures. There was no statistically significant difference in the number of errors made by the two groups on the portion of the final examination used as a criterion.

Conclusions and Recommendations

The results of the present study indicate that use of chemically treated answer sheets leads to a decrease in time taken by students to reach a predetermined criterion level. In view of the reduction in training time, the ease in test scoring, and the wide range of application for the paper, it is recommended that existing instructional programs be closely examined with regard to the possible advantages of incorporating chemically treated answer sheets into the programs.

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AN EVALUATION OF THE USE OF CHEMICALLY TREATED ANSWER SHEETS

A. Problem

The present study was undertaken in an effort to assess the feasibility of using chemically treated answer sheets within courses developed as part of the CMI (Computer Managed Instruction) Project at the Naval Technical Training Command, Memphis.

The chemically treated answer sheets are designed so that marks with a special marker will uncover the latent image answers printed on the sheets. Thus, the student sees, immediately after making a response, whether his answer is correct. If the response is incorrect, he may then mark other alternatives until he finds the correct answer. Thus, the student is provided with immediate knowledge of the correct answer to each question, but there is no way for him to look ahead or cheat before recording his answer. Since the answer sheet is self scoring, it can be used to provide an immediate indication of the areas in which the student needs remediation. A sample sheet (reduced in size) is reproduced in Appendix A.

The value of these features was determined by comparing the performance of a group of students who used the chemically treated answer sheets in part of the AMFU (Aviation Mechanical Fundamentals) Course with the performance of a group of students who used optically scannable answer sheets in learning the same material.

B. Approach

1. General Procedures

The course is broken down into blocks of instruction called modules. When a student completes a module, he takes an exhaustive test that covers every objective in the module. If he meets criterion on each of the general areas (or groups of objectives) covered by the test, he proceeds to another module. If he fails to meet criterion on one of the general areas, he is assigned a remedial test that covers that area. He does whatever remedial work he feels to be required in order to correct his deficiency, then takes the remedial test. When he has passed tests on all modules within the course, he takes the end-of-course examination.

2. Control Group

Students in the Control Group were assigned several modules at a time. It was suggested that the students work through the modules in the order in which they were listed, but the students were actually free to work on any of the assigned modules. The students in this group responded to their tests on optically scannable answer sheets. When they finished a test, they

deposited the answer sheet in a basket for subsequent pickup by the computer operator. The student, meanwhile, continued with other assignments. The answer sheets were collected every 20 minutes for evaluation by the computer. The average delay between the completion of a test and the receipt of feedback from the computer was about 30 to 40 minutes.

If a student did not meet criterion on the initial test following a module, the feedback consisted of a list of the general areas on which he had not met criterion and a remedial test assignment for each of these areas. If he did meet criterion, he received no feedback. Feedback on the remedial tests consisted of (1) a list of any items he might have missed and (2) either a statement that he had met criterion or another remedial test assignment.

3. Experimental Group

Students in the Experimental Group used the chemically treated answer sheets, but only during the first half of the course; during the second half they used the optically scannable answer sheets. When the student finished one of the chemically treated answer sheets, he took it directly to a monitor for evaluation. If he did not meet criterion on one of the general areas, he was told the area in which he was deficient and was assigned a remedial test on that area; if he did meet criterion on all areas within a module, he was assigned a new module. Since there was little or no delay between the completion of a test and feedback on the test, students were assigned only one module at a time.

4. Subjects

The Experimental Group consisted of 19 Navy enlisted men who went through the CMI version of the AMFU course. The Control Group consisted of 46 Navy enlisted men.

5. Method of Evaluation

The two groups were compared in terms of (1) the time required to complete the first half of the course and (2) the number of errors made on those items from the end-of-course examination which pertained to material covered during the first half of the course. The latter consisted of 233 of the 490 end-of-course test items. These items provided an extensive coverage of all objectives taught during the first portion of the course. The difference on each criterion was tested by means of an analysis of covariance in which a composite of scores from the Navy Basic Test Battery was used as the control variable. The composite was determined on the basis of data collected from previous students in the course.

C. Results and Discussion

Table 1 contains both the mean and adjusted mean training time (in hours) for each group in the first segment of the course. Table 2 contains the analysis of variance and covariance on these same data.

TABLE 1

Mean and Adjusted Mean Training Time for
Groups E and C in Course Segment I

	<u>Original Means</u>	<u>Adjusted Means</u>
E	21.8	21.5
C	25.0	25.3
Difference	-3.2	-3.8

TABLE 2

Analysis of Variance and Covariance on Measures of
Training Time for Segment I

Source of Variation	SS	df	MS	F
Groups	138.3303	1	138.3303	5.7094*
Error	1526.3932	63	24.2285	
Total	1664.7235	64	26.0113	
Groups (adj.)	191.9713	1	191.9713	9.0776**
Error (adj.)	1311.1624	62	21.1478	
Total (adj.)	1503.1337	63	23.8593	

Notes --

* Significant at .05 level of confidence

** Significant at .01 level of confidence

The Experimental Group was found to require reliably less training time in the first segment of the course than the Control Group, both before and after adjustment for differences in aptitude. The data indicate that training time was reduced about 15% by means of the chemically treated paper and associated changes in procedures.

Table 3 contains both the mean and adjusted mean number of errors on the final examination for each group on the material taught in the first segment of the course. Table 4 contains the analysis of variance and covariance on these data. There was no statistically significant effect, either before or after adjustment.

TABLE 3

Mean and Adjusted Mean Number of Errors on End-of-Course Test for Groups E and C on Material Taught in Course Segment I

	<u>Original Means</u>	<u>Adjusted Means</u>
E	13.8	13.4
C	11.3	11.7
Difference	2.5	1.7

TABLE 4

Analysis of Variance and Covariance on End-of-Course Error Scores for Segment I

Source of Variation	SS	df	MS	F
Groups	81.5949	1	81.5949	1.5830
Error	3247.2666	63	51.5439	
Total	3328.8615	64	52.0135	
Groups (adj.)	35.0635	1	35.0635	.7611
Error (adj.)	2856.2893	62	46.0692	
Total (adj.)	2891.3528	63	45.8945	

D. Conclusions and Recommendations

The results of the present study indicate that use of chemically treated answer sheets led to a decrease in time taken by students to reach a predetermined criterion level. No effect on a criterion referenced end-of-course test was detected.

It is possible that the reduction in training time could be due as much to the sequential administration of materials as it is to the chemically treated answer sheet itself. However, the sequential administration (where the student was forced to meet criteria on one subject area before continuing to another) was made administratively possible by the self scoring property of the chemically treated answer sheets. Also, the students were not allowed to proceed until they had found the correct answer to each question. This particular feature serves as a significant aid in the debugging of tests.

The immediate feedback provided to the student is another advantage of using the chemically treated paper. Without such item by item feedback, the student has to return to the test after an elapsed period of time, reconstruct the question and how he derived a particular answer, and then locate the correct responses within the appropriate instructional material. In this respect the chemically treated answer sheets aid the instructional process and contribute to the savings in time.

A larger number of personnel was required for running the Experimental Group than for the Control Group. The additional personnel were needed for checking test performance against established criteria, recording test results and assignments, and making new or remedial assignments. However, the chemically treated answer sheets used in conjunction with computer assignment and evaluation eliminates the need for such extensive recordkeeping and manual assignment.

Notes on the cost of using chemically treated answer sheets may be found in Appendix B.

In addition to the reduction in training time associated with the use of the chemically treated answer sheets and the ease in test scoring, the paper seems to have a wide range of application and, in general, is favorably accepted by students and instructors alike. Thus, it is recommended that a close look be taken at existing instructional programs with regard to the possible advantages of incorporating chemically treated answer sheets into the instructional and/or testing phases of the programs.

APPENDIX A

Sample CMI Answer Sheet

NAVY CMI ANSWER SHEET CMI-14

NAME — LAST	FIRST	INITIAL	RANK/RATE	CO/BAT #	JULIAN DATE	SCORE
TEST FORM	SCHOOL	CLASS NO			INSTRUCTOR	

S O C I A L S E C U R I T Y	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9

T E S T	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9

C O O R D I N A T E	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9

Z O N E	1	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8	9

THE LETTER ☐ WILL APPEAR WHEN YOU MARK THE CORRECT ANSWER

A 4835

1	W	1	2	3	4	5
2	W	1	2	3	4	5
3	W	1	2	3	4	5
4	W	1	2	3	4	5
5	W	1	2	3	4	5
6	W	1	2	3	4	5
7	W	1	2	3	4	5
8	W	1	2	3	4	5
9	W	1	2	3	4	5
10	W	1	2	3	4	5
11	W	1	2	3	4	5
12	W	1	2	3	4	5
13	W	1	2	3	4	5
14	W	1	2	3	4	5
15	W	1	2	3	4	5
16	W	1	2	3	4	5
17	W	1	2	3	4	5

18	W	1	2	3	4	5
19	W	1	2	3	4	5
20	W	1	2	3	4	5
21	W	1	2	3	4	5
22	W	1	2	3	4	5
23	W	1	2	3	4	5
24	W	1	2	3	4	5
25	W	1	2	3	4	5
26	W	1	2	3	4	5
27	W	1	2	3	4	5
28	W	1	2	3	4	5
29	W	1	2	3	4	5
30	W	1	2	3	4	5
31	W	1	2	3	4	5
32	W	1	2	3	4	5
33	W	1	2	3	4	5
34	W	1	2	3	4	5

35	W	1	2	3	4	5
36	W	1	2	3	4	5
37	W	1	2	3	4	5
38	W	1	2	3	4	5
39	W	1	2	3	4	5
40	W	1	2	3	4	5
41	W	1	2	3	4	5
42	W	1	2	3	4	5
43	W	1	2	3	4	5
44	W	1	2	3	4	5
45	W	1	2	3	4	5
46	W	1	2	3	4	5
47	W	1	2	3	4	5
48	W	1	2	3	4	5
49	W	1	2	3	4	5
50	W	1	2	3	4	5

APPENDIX B

NOTES ON THE COST OF CHEMICALLY TREATED ANSWER SHEETS

Meaningful cost estimates, of course, are dependent upon the amount of chemically treated paper required for a course and the volume of paper to be ordered.

Students going through the course under consideration in the present study use an average of 64 sheets for the complete course. This includes remedial tests taken after the end-of-course test. The average time taken to complete the course (and end-of-course remedials) is 6 days.

Costs for reorder of the chemically treated optical scan sheets are as follows: 300,000 sheets may be ordered for a cost of \$24.50 per thousand sheets (2.5 cents per sheet); 1,500,000 sheets may be ordered for \$16.04 per thousand (1.6 cents per sheet). These figures, of course, do not include the plate costs or costs for preparation of camera-ready copy. However, these latter are one-time costs which would not be involved in a reorder.

The costs for an initial order of chemically treated answer sheets can be broken down as follows:

1. Preparation of camera-ready copy is \$175 for each basic form (i.e., for each answer sheet design) and \$23 for each individual answer pattern. In the present study 16 different answer patterns were prepared. For each pattern, five latent letters were randomly distributed among the alternatives for each item on the basic form. Each of the five letters could then be used as a key for correct answers. Therefore, each individual answer pattern provided five different correct answer patterns. The basic design also had columns which could be optically scanned.
2. Plate costs are approximately \$120 for two plates, one plate for the visible ink and one for the latent. Four 8 1/2" X 11" sheets are printed per impression. Thus, four individual answer patterns may be obtained from two plates.
3. The cost of 1,000 crayon imaging markers is approximately \$100.

The following cost estimates are for optical scan sheets which do not provide immediate knowledge of results (i.e., are not chemically treated):

1. Sheets printed on one side only are \$100 for the first thousand copies and \$6.05 for each additional thousand. (If

camera-ready copy is provided, the \$100 estimate for the first thousand would be reduced to \$35.) The cost per sheet on large runs, therefore, would be $\$6.05 \div 1,000$ or .6 cents per sheet.

2. Sheets printed on both sides are \$165 for the first thousand copies and \$7.59 for each subsequent thousand. (If camera-ready copy is provided, the \$165 estimate would be reduced to \$47.55.) Thus, the cost per sheet on large runs would be $\$7.59 \div 1000$ or .76 cents per sheet.

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